Onsite Wastewater Treatment Systems Technology Fact Sheet 6

Evapotranspiration and Evapotranspiration/Infiltration

Description

Onsite evapotranspiration wastewater treatment systems are designed to disperse effluent exclusively by evapotranspiration. Evapotranspiration (ET) is defined as the combined effect of water removal from a medium by direct evaporation and by plant transpiration. The evapotranspiration/infiltration (ETI) process is a subsurface system designed to dispose of effluent by both evapotranspiration and infiltration into the soil. Both of these systems are preceded by primary pretreatment units (e.g., septic tank) to remove settleable and floatable solids. The influent to the ET or ETI units enters through a series of distribution pipes to a porous bed. In ET systems, a liner is placed below the bed to prevent water loss via infiltration unless the soil is impermeable. The surface of the sand bed is planted with water-tolerant plants. Effluent is drawn up through fine media by capillary wicking and evaporated or transpired into the atmosphere. In ETI systems, effluent is allowed to percolate into the underlying soil.

Modifications to ET and ETI systems include mechanical evaporating devices and a broad array of different designs and means of distribution, storage of excess influent, wicking, and containment or infiltration prevention. Some newer studies are using drip irrigation with distribution to forested areas with purported success.

Typical applications

ET and ETI systems are best suited for arid (evaporation exceeds precipitation) climates. If ETI is selected, soil percolation is also an important consideration. Both systems are often selected when site characteristics dictate that conventional methods of effluent disposal are not appropriate (e.g., unprotected sole source aquifer, high water table or bedrock, tight soils, etc.).

Although these systems normally follow septic tanks, additional pretreatment may be employed to minimize clogging of the ET/ETI system piping and media. They are sometimes used as alternative systems during periods when normal disposal methods are inoperable, for example, spray or other surface irrigation. Also, these systems have been widely used for seasonal homes in areas where year-round application of ET/ETI is not practical and conventional methods are not feasible. Year-round ET systems (see figure 1) require large surface areas and are most feasible in the areas shown on figure 2. ETI systems can be employed to reduce the infiltrative burden on the site during the growing season. Such applications can also result in some reduction in nutrients, which are transferred to the overlying vegetation (USEPA, 1999).

Figure 1. Cross section of a generic evapotranspiration bed (adapted from NSFC)

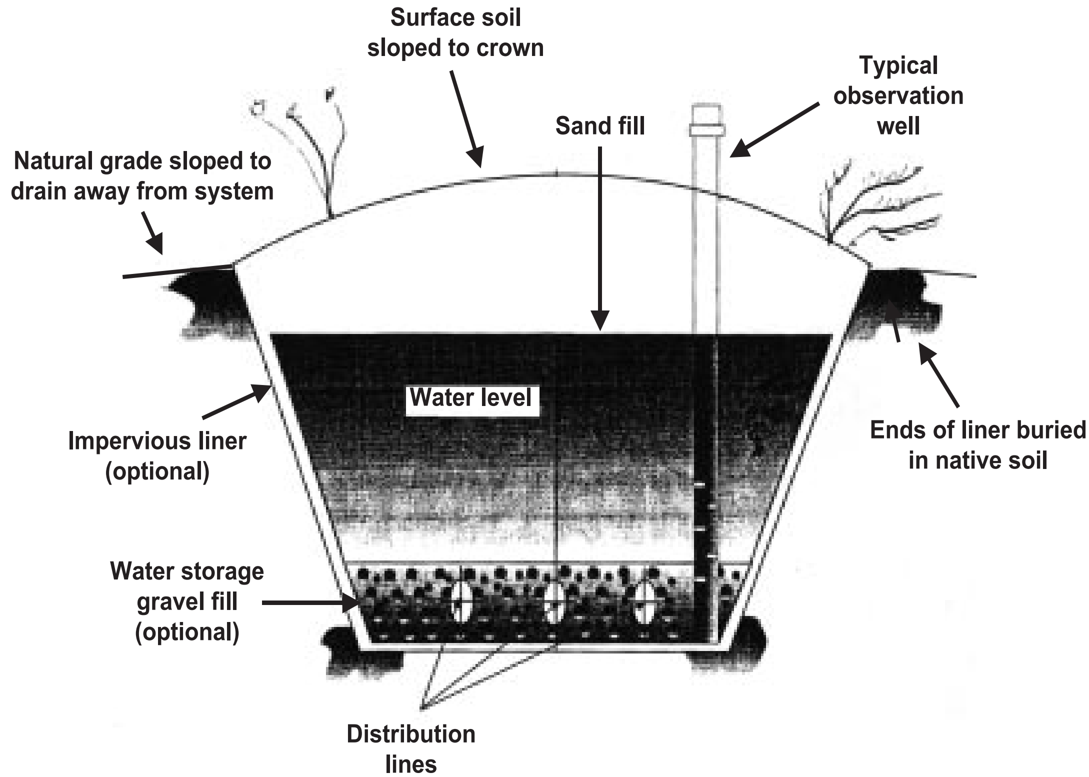
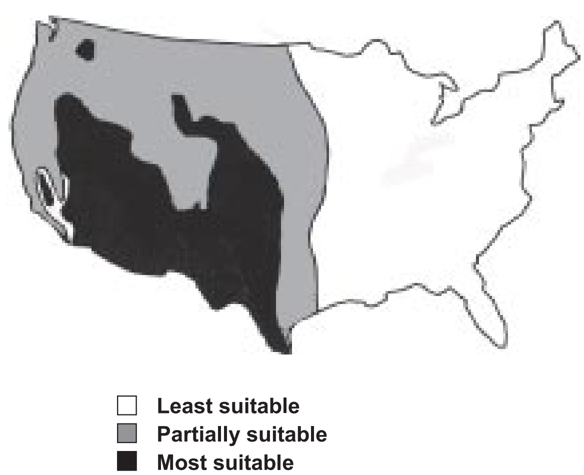


Figure 2. Relative suitability for evapotranspiration systems



Design assumptions

The design evapotranspiration rate is site specific. Some areas are arid (precipitation < evaporation) but lack the solar radiation or wind velocities necessary to efficiently evaporate wastewater throughout the year. Therefore, simple use of well-known evaporation estimates like Pentman, Blaney-Criddle, and Jensen-Haise will not likely be satisfactory. In fact, historically, the definition of workable ET rates for an area has been a trial and error process, which is further complicated by the system design and the plants used. The primary variables that have an impact on the potential ET rate are climate, cover soil, and vegetation. The most important system variables, which control the movement of wastewater to the surface, are media and the depth to saturated (stored) water. Most published designs are suspect because they store the wastewater so deep that the wicking properties of the fill and the area (voids) through which water must rise restrict delivery of water to the surface where it is evaporated.

Present ET system designs normally employ 20-mil polyethylene liners where the soil is too permeable and ground water contamination is likely. Most employ distribution systems placed in 12 inches of gravel (0.75 to 2.5 inches) at the bottom of the bed. Spacing of the distribution pipes is 4 to 12 feet, with lower values preferred for better distribution. Wicking is accomplished by a 2- to 2.5-foot layer of sand (0.1 millimeter) and a loamy soil-sand mix to raise the water to the surface or a thin layer of soil at the surface. Most have employed the formula:

$$\mathbf{A = nQ/ET - P}$$

where:

A = surface area required to evaporate the wastewater
n = coefficient, which varies from 1 to 1.6
Q = annual flow volume
ET = annual evapotranspiration rate
P = annual precipitation rate

Each of these factors is open to some degree of interpretation. Because these systems are large and expensive, there has been a tendency to minimize their design size and cost, resulting in significant failure rates. Typical ET estimates range from 0.01 to 2.0 centimeters per day. The contribution of plants has remained a matter of controversy. ET bed sizing has varied from 3,000 to 10,000 square feet and higher. A water balance based on at least 10 years of data is calculated to provide sufficient storage for nonsurfacing operations or to estimate nonatmospheric volumes to be infiltrated.

The modern use of shallow trenches for SWIS is strongly related to the maximization of ET, and such systems could be classified as ETI systems. Further, the use of shallow serial distribution where topographic relief is available is a classic application of the ETI concept, that is, shallow trenches close to the surface, full of wastewater, with only a short wicking distance to the evaporative surface. Such a system fulfills all the described features of an ideal ETI system. Similarly, drip irrigation uses the shallowest of all SWIS burial requirements and, by nature, maximizes ET potential.

Performance

There have been few studies of ET and ETI systems. Most ET system studies have been less than impressive. In most cases the fault has been related to poor design assumptions, for example, over-estimating the ET potential of shrubs and trees planted on the surface and of the overall potential of ET itself. Poor system design has been somewhat offset by leaking liners that give the appearance that the system is performing adequately. Inadequate wicking has been overcome by raising water levels. However, better ET assessment and more rational designs will improve performance at increased costs.

ETI systems have generally worked well, but no scientific studies have been performed to verify this observation. ETI systems do fail when the ET contribution is overestimated, but many times the placement of the wastewater higher in the soil profile offsets that error by increasing the infiltrative capacity of the site.

Management needs

ET systems are very sensitive to variations in construction techniques. Poor construction can defeat their utility through poor liner installation, poor placement and choice of wicking media, compaction, and inadequate surface drainage mitigation.

Operation and maintenance requirements are minimal, often consisting of simply mowing the grass on the surface. Replanting cover crops to improve cold season performance has been suggested but offers little return. Shrubs or small trees planted on the ET system generally improve active (warm) season ET and hinder ET in the dormant (cold) season. Therefore, the O/M needs of the system should be limited to two to three short visits to observe and record the water height in the observation well. These tasks require about 1 to 2 hours per year of unskilled labor. No energy is required. ET system salt buildup, if not diluted by precipitation, may require some media replacement after 5 to 10 years of operation depending on water supply characteristics. There are no known safety issues with these systems as long as they are fenced or otherwise isolated from children's play areas.

ETI systems are very similar to SWIS systems, and their management requirements are similar to those of ET systems. Because ETI systems infiltrate wastewater, they have ground water and surface water contamination concerns like those of other SWIS designs, and they may require monitoring of effluent impacts depending on the uses of ground water and performance standards to protect them.

Risk management issues

Because ET systems are large, there may be some visual aesthetic problems. Odors are usually not a problem, but they can be on occasion. Flow peaks during low ET periods could result in overflows, thus leading to the usual restriction for year-round ET use in areas where ET does not exceed precipitation by more than 2 inches per month. These systems do not function when their surface freezes. They are typically unaffected by power outages since they are generally fed by gravity. Toxics also have no impact unless they are phytotoxic and would then kill the surface vegetation.

Costs

Because of their large size and specific media (and often liner) requirements, ET systems are generally expensive, reinforcing their use as a "last resort" alternative. Installed costs of $10,000 to $15,000 and higher are possible depending on climate and location. O/M costs are relatively low, on the order of $20 to $30 per year, but they could increase if the system fills and requires pumping. ETI systems have capital and O/M costs similar to a SWIS.

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